Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

Circular No. 762

The Small Rural Industry
A Study of the Possibility of Making Insulating Board From Straw

E. C. LATHROP, Principal Chemical Engineer

T. R. NAFFZIGER, Chemical Engineer

and

R. V. WILLIAMSON, Senior Chemical Technologist

Northern Regional Research Laboratory, Peoria, Ill.
Bureau of Agricultural and Industrial Chemistry
Agricultural Research Administration

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.
Price 15 cents

UNITED STATES DEPARTMENT OF AGRICULTURE

WASHINGTON, D. C., AUGUST 1947

LIBRARY
RECORD
NOV 12 1947
U. S.

FOREWORD

Considerable interest has been manifested in the establishment of new rural industries as a means of securing greater stability in the rural community. This bureau has received requests for information concerning the feasibility of establishing some of the following rural industries: Soybean crushing for oil production, production of corn and malt sirups, production of wall board, dry milling of corn, production of starch and alcohol, etc. This analysis dealing with insulating board production is a case study directed primarily to a determination of the technological, economic, and business factors that must be considered and evaluated in such industrial development.

Any study of the establishment of a rural industry to manufacture salable products from farm materials or residues which are not feed or food products, must include much more than an appraisal of the manufacturing process itself. Time and work would be wasted and perhaps irreparable harm done to those who might attempt such manufacture, unless all factors—such as availability of materials, location, potentials of the local trade territory, labor conditions, fixed costs, selling costs, manufacturing facilities, and the probable competitive situation—were carefully analyzed and evaluated in advance.

It is not enough to know that manufacturing is possible; manufacture in itself may be among the lesser problems that a new rural industry must face. It is important that any attempt to establish rural industries should not be made blindly; and studies relating thereto, such as this one, should seek to present an accurate appraisal of the hazards as well as the possibilities of success.

This case study has brought clearly into focus some of the main problems to be encountered in developing and establishing a rural industry for making a product that is already manufactured by mass-production methods and is skillfully advertised and merchandised. Obviously, a like analysis must be made for each rural industrial process development; each presents a separate case, but the requirements of sound business management, ability to merchandise at a profit, and ability to manufacture a competitive product are common to all.

L. B. Howard,
Chief of Bureau.

Circular No. 762

August 1947 Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE

The Small Rural Industry—A Study of the Possibility of Making Insulating Board From Straw

By E. C. Lathrop, *principal chemical engineer*, T. R. Naffziger, *chemical engineer*, and R. V. Williamson, *senior chemical technologist, Northern Regional Research Laboratory, Peoria, Ill., Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration*

CONTENTS

	Page
Introduction	1
Large-scale versus small-scale manufacturing operations	2
Pilot-plant studies	3
Process No. 1. A 25/32-inch board composed of straw and Portland cement	3
Process No. 2. Production of a felted strawboard with simple equipment that can be made or assembled locally	4
Process No. 3	6
Economic studies	12
Estimates of manufacturing cost	12
Merchandising and estimated profit	18
Conditions required for successful operation	20
Summary	22

INTRODUCTION

Fibrous agricultural residues are particularly well suited for the manufacture of structural insulating boards. Several billion square feet of such insulating boards were produced in the United States from sugarcane bagasse, cereal straws, and cornstalks, from 1921 to 1945, inclusive. The farm and the rural community represent an important and established market for insulating board. Surveys relating to postwar building requirements point to the magnitude of the potential market for new farm structures as well as to the need for remodeling and repairing old buildings.

An important goal of the Regional Research Laboratories is the development of new small rural industries using agricultural products—a goal that has been greatly emphasized in postwar planning. In general, established rural industries are confined either to the initial processing of raw materials or to manufacturing bulky or perishable products for local consumption. They do not compete greatly with large centralized manufacturing operations. This is due in part to the perishable nature of the agricultural commodities, and in part to the fact that the product is sold only in the local trading

area. Agricultural commodities not suited for feed or food, such as agricultural residues, are used to a limited extent in large-scale manufacture of board and paper products; their wider use has been limited by high costs of collection and transportation.

The establishment and development of new rural industries for making nonfood products, such as making insulating board from straw, present technical, economic, and business problems that must be considered seriously before a plant is established. These new industries, quite often, must compete locally with large manufacturers of similar products made by mass-production methods and skillfully merchandised with the aid of national advertising and sales service. The successful establishment of a specific rural industry therefore will depend to a considerable extent on how well the problems arising from such competition can be evaluated and solved.

As an example of the development of a potential rural industry, a technical and economic study has been made of the small-scale manufacture of insulating board from straw. It is believed that the problems encountered and the deductions drawn in this study will be a contribution to the general subject of rural industrial development. An answer was sought to three questions: What technical problems must be solved in establishing an insulating-board industry? What is the smallest-sized unit for the manufacture of standard-quality insulating board that can compete under existing conditions? Under what set of business and economic conditions would the venture be most likely to succeed?

LARGE-SCALE VERSUS SMALL-SCALE MANUFACTURING OPERATIONS

The problem of developing a manufacturing process for the rural industry requires a very different approach from that used for mass production.

Insulating materials, whether made from agricultural residues or wood fiber, are manufactured by highly efficient mass-production methods that have resulted from improvements in machines, control instruments, and labor-saving devices developed within the industry over the past 35 years. These methods make possible the production of uniform and high-quality products. The manufacturing operations, except for Sunday shutdown, are continuous, almost automatic. Although the machines and control instruments are expensive, manual labor is largely eliminated, and the production capacity of each unit is so high that capital and operating expenses per 1,000 square feet of production are low. The plants are favorably located for low-cost raw materials, power, and water supply. A plant of this character having a production capacity of much less than 75,000 square feet per day of one-half inch board is generally considered uneconomical to operate. The cost of a plant of this size would be in the neighborhood of $750,000, and its output is far too large for complete use of the product in even a large rural trading area. Each member of the industry produces a wide range of board, lath, sheathing, and interior-finish products. Because the rural plant will have a

fixed efficient production capacity, its location will be dependent on finding a local trading area where complete sale and use of the product can be realized. The manufacturing process and machinery must be simple, inexpensive, and as foolproof as possible, in order that a standard and uniform product may be produced and maintenance and repairs may be carried on locally. Capital investment must be kept low, so that fixed charges on machinery, buildings, and inventories may be kept at a minimum. This is necessary in order to offset labor costs which are bound to be high, and to insure against high losses resulting from fixed charges during periods of idleness. The kinds of products manufactured should be limited preferably to one or two or three at the most, to insure a sales outlet for rejects. The size of the plant and its production capacity will dictate the character and location of the trading area. A plant with a high capital investment would probably require 24-hour, 300-day-per-year operation, and one with a low capital investment would permit more intermittent or seasonal operation in spite of high labor costs. Thus, to obtain production at a profit, the best possible balance between fixed charges and labor costs must be found.

PILOT-PLANT STUDIES

Wheat straw was selected as the residue to be used as the raw material for the following reasons: (1) It is produced in great tonnage in many parts of the United States; (2) satisfactory machinery and methods exist for its collection and storage; (3) there is a long industrial background for its use in paper and board products; and (4) it is relatively free from pith and cooks easily to produce long fibers. It was believed that after a process was perfected for making board from wheat straw it would be possible also to use other straws, cornstalks, bagasse, and other fibrous residues with some modification in the process.

Process No. 1 A $^{25}/_{32}$-inch Board Composed of Straw and Portland Cement

During the past 10 years national manufacturers have marketed a product known as $^{25}/_{32}$-inch insulating sheathing board which is particularly useful for the insulation of farm structures and houses. The product has the thickness of dressed lumber and, when applied as sheathing, produces structures not only well insulated against heat, cold, and drafts but also as rigid as those sheathed with lumber. The sheathing board is coated with asphalt, on one or both sides, to produce greater weather resistance. This product was chosen as well suited for manufacture by a rural industry.

The first process investigated was one thought to involve the least capital investment in machinery and buildings. It was planned to use machines that are in general use on the farm or in the rural town, such as ensilage choppers, shredders, cement mixers, etc. For many years satisfactory building materials having some insulating value have been made in Europe and also in this country by coating wood excelsior with

a slurry of either magnesite cement or Portland cement, placing the mix in suitable molds, allowing the cement to set and dry, and then removing the boards or blocks from the molds. In Europe a product known as Heraklith was manufactured in this manner. In the United States a similar product known as Thermax, is manufactured in considerable volume.

It was found that the use of straw presented very serious problems not encountered with excelsior. When straw, shredded or chopped to various lengths, was mixed, before or after cooking, with various proportions of cement slurry in a cement mixer and then molded into boards, the bond between the cement and straw was very weak. Among many chemicals tried, sodium silicate of the grade used as egg preservative, mixed with chopped straw prior to addition of the cement slurry, produced the best bond. The board thus formed was very heavy, about 3 pounds per square foot. It could be nailed and sawed, but it was no stronger than a board made by felting straw fibers together in the absence of cement. The board could not be waterproofed and would not take ordinary paint satisfactorily because of its strongly alkaline character. Furthermore, raw-material costs alone were estimated at $30 per thousand square feet. After hundreds of trials during more than a year, this process was finally abandoned as impractical from both the quality and cost standpoints.

Process No. 2. Production of a Felted Strawboard With Simple Equipment That Can Be Made or Assembled Locally

The second process investigated was based on the general principles used in large-scale manufacture of insulating board, namely, cooking straw under mild conditions, shredding and washing the cooked straw to produce a water suspension of fibers, adding rosin size and alum to impart water resistance, forming a board by felting the fibers on a wire screen while the water drains away, pressing out the excess of water, and then drying the board.

It is necessary to produce fibers of suitable length and stiffness and at the same time to bring about a certain amount of swelling of the fibers. When the wet board dries, the felted mass of fibers shrinks together, and thus strength characteristics are produced. The proper mixture of fibers and the amount of water removed during the drying of the board govern its density and, therefore, its insulation value. In order to produce a board of uniform thickness and density, it is necessary to have means for measuring a definite weight of fiber into each square foot of board. The product was required to meet the following specifications:

Thickness	$25/32 \pm 1/64$ inch.
Density	0.26 to 0.31 as compared to water.
Tensile strength	Minimum, 175 pounds per square inch.
Modulus of rupture	Minimum, 200 pounds per square inch.
Waterproofness	Not more than 60 percent by weight of water shall be absorbed after 24-hour immersion in distilled water.

The machinery used for producing the board must be simple and easily assembled or constructed by local mechanics. In order to control the amount of straw used in each board, chopped straw sufficient

for one board was weighed into a wire basket which was lowered into a 50-gallon iron drum containing 8 percent caustic (on weight of dry straw) as a 1-percent solution. The charge was heated to boiling for 15 minutes by steam passed through a coil in the bottom of the drum. After the cooking, the basket was raised out of the solution to a position above the drum and, while draining, was sprayed with sufficient cold water to bring the solution in the drum back to its original volume. The used caustic solution in each of the drums was fortified with fresh caustic 16 times before being discarded.

The drained straw was mixed with water, passed through a hammer-mill shredder, and washed as well as possible for 5 minutes with water, after which the caustic remaining in the straw was neutralized carefully with diluted sulfuric acid. Water to make a 2-percent suspension was added to the washed fiber; then dry rosin size and alum solution were added separately, each being mixed thoroughly with the fiber suspension. This suspension was flowed onto a wire screen in a forming box, and the drainings were returned for use at the shredder. The wet board was pressed while in the forming box by a wooden platform lowered upon the top of the pulp (fig. 1), pressure being applied by means of automobile jacks worked by hand.

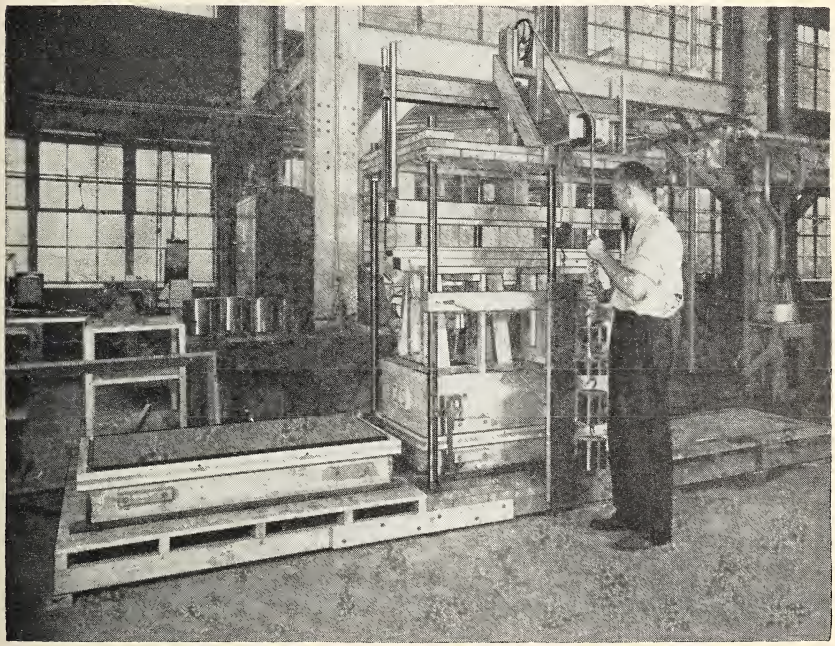

FIGURE 1.—Board machine for Process No. 2.

It is difficult to felt a uniform board. However, while the formation obtained was by no means perfect, an acceptable board could be made in this fashion. After being pressed, the wet board contained about 82 percent of water; hence, 4.5 tons of water would have to be evaporated for each ton of board produced. Experiments made in an

attempt to dry the board by the circulation of warm air indicated that several days would be required and that such a procedure would make the cost of drying racks exceedingly high. It became evident that a steam drier would be required in the operation and that this would necessitate the employment of firemen during the entire 24 hours. This, in turn, would make 24-hour operation of the whole plant an obvious necessity. An analysis of the costs of production, based on forming a board every 5 minutes as determined by time studies on a pilot-plant operating scale, gave an estimated cost per 1,000 square feet of $42.10. This was divided as follows: Straw and chemicals, $11.02; steam and power, $6.22; labor, $20.38; and fixed charges, $4.48. The estimated equipment cost of the operation was $23,000, and the cost of buildings $9,000.

The basic difficulty with this process was that each batch of straw had to be handled separately through all operations in order to control the board's properties. The short time schedules for each batch in the various steps required too much labor and, obviously, control was likely to be inexact and uncertain. The equipment cost of the boiler and drier alone amounted to $10,000, about half of the total equipment cost. This process was therefore abandoned in favor of one using equipment much more like that used in large operations.

Process No. 3

This process was designed to produce the same product as Process No. 2, but to operate 24 hours per day, with three shifts, and 300 days per year. The same boiler and drier required for Process No. 2 was used.

In this process, as finally worked out, chopped straw sufficient for the entire production during an 8-hour shift is blown into a 9-foot rotary globe cooker (see fig. 2 for illustration of a 3-foot pilot-plant cooker) and cooked for 1 hour at 50-pounds steam pressure, with lime and caustic soda solution. The cooked pulp is conveyed mechanically to a metering box that feeds a wet shredder. The shredded straw is washed through a rotary washer (fig. 3) and dropped into a stock tank provided with an agitator. The tank is capable of holding sufficient 2-percent fiber suspension to supply the board machine for the production of 1,500 square feet of board in 8 hours. This procedure reduces the cost of straw and chemicals by $4.51 per 1,000 square feet. It also reduces the amount of sulfuric acid required for neutralization of the caustic soda and the amount of sizing chemicals. By providing two stock tanks, a full shift of 8 hours is available for cooking and preparing the fiber, which makes possible exact control of the operation. The amount of fresh water required is greatly reduced by re-use of water. Furthermore, only one man is required per shift for this work of fiber preparation.

A new machine to produce a board 3 by 3 feet was designed, built, and operated. Roller conveyors were provided for moving a rack containing the screen on which the board is formed into the forming box, and from there into the press. (See figs. 4, 5, and 6.) After the boards are pressed, the racks containing them are placed one above the other and dried in a tunnel drier. (See fig. 7.) A metering-head box (fig. 5)

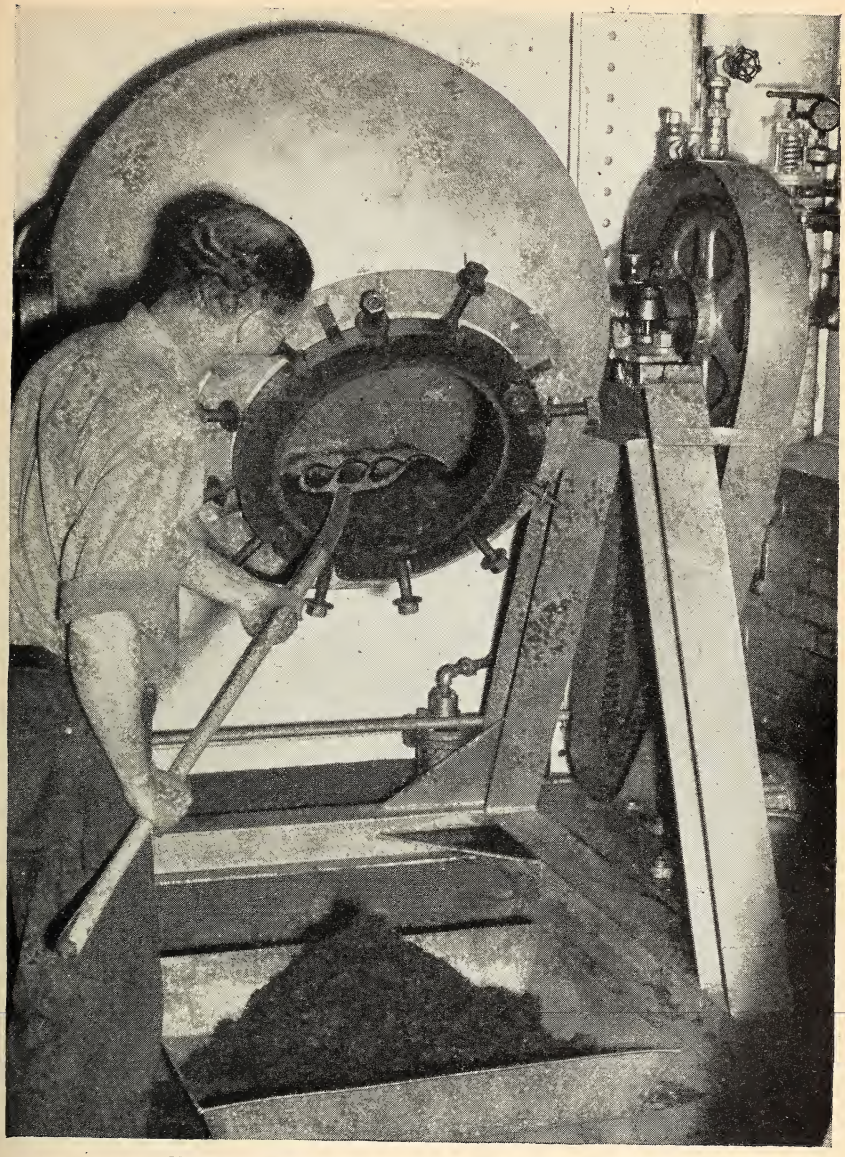

FIGURE 2.—Three-foot rotary pilot-plant cooker.

758823°—47——2

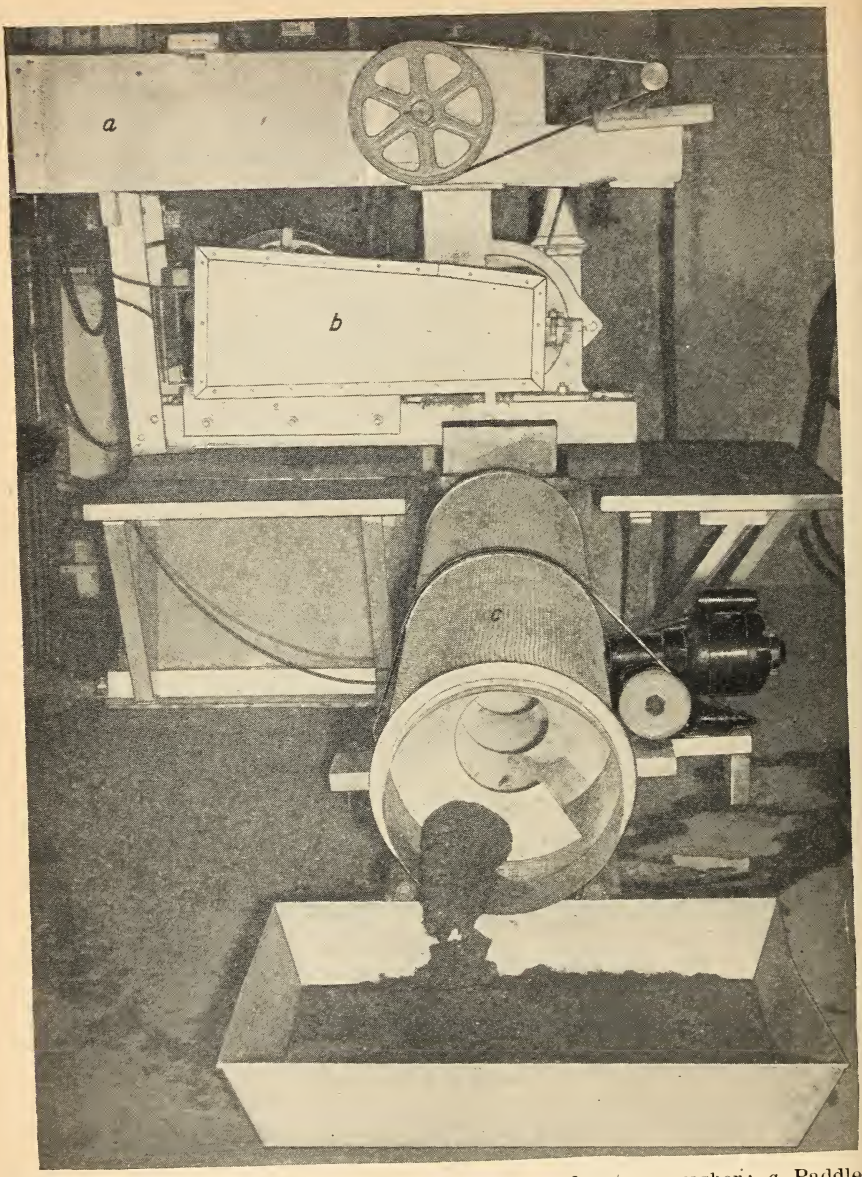

FIGURE 3.—Metering box, pilot-plant shredder, and rotary washer: *a* Paddle wheel metering device, *b* shredder, *c* rotary washer.

was provided to insure automatically the flow of the exact volume of fiber mixture into the forming box. The "white water" draining from the board was pumped to a stock tank for re-use. The wet board was pressed at 25 pounds per square inch while resting on the screen; in this

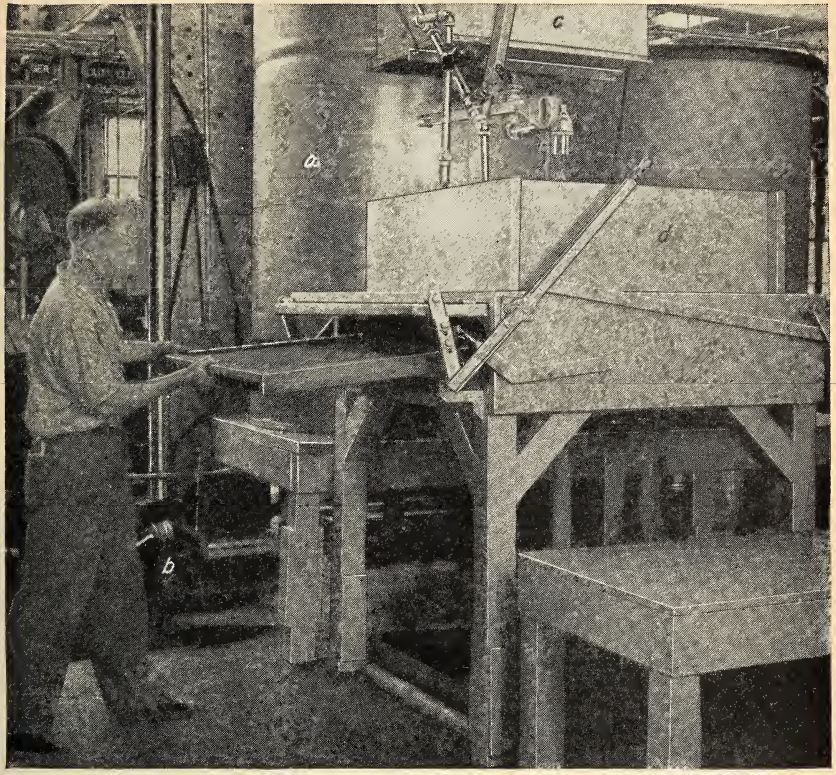

FIGURE 4.—Pilot-plant board machine, forming screen being put in place: *a* Stock tank; *b* circulating pump; *c* metering-head box; *d* board machine.

way its moisture content was reduced to 75 percent. Although 3 tons of water still had to be evaporated during drying to produce 1 ton of board, pressing reduced the drying cost by $1.34 per 1,000 square feet. The top platen of the press was designed to have a square retaining band which prevents the wet pulp being squeezed out during pressing and thus controls the board dimensions.

Several minor but difficult problems had to be solved. Difficulty was experienced in obtaining good formation of the wet board. Use of a spreader for directing the flow of the water-fiber suspension into the forming box overcame this difficulty. By using a paddle-wheel meter-

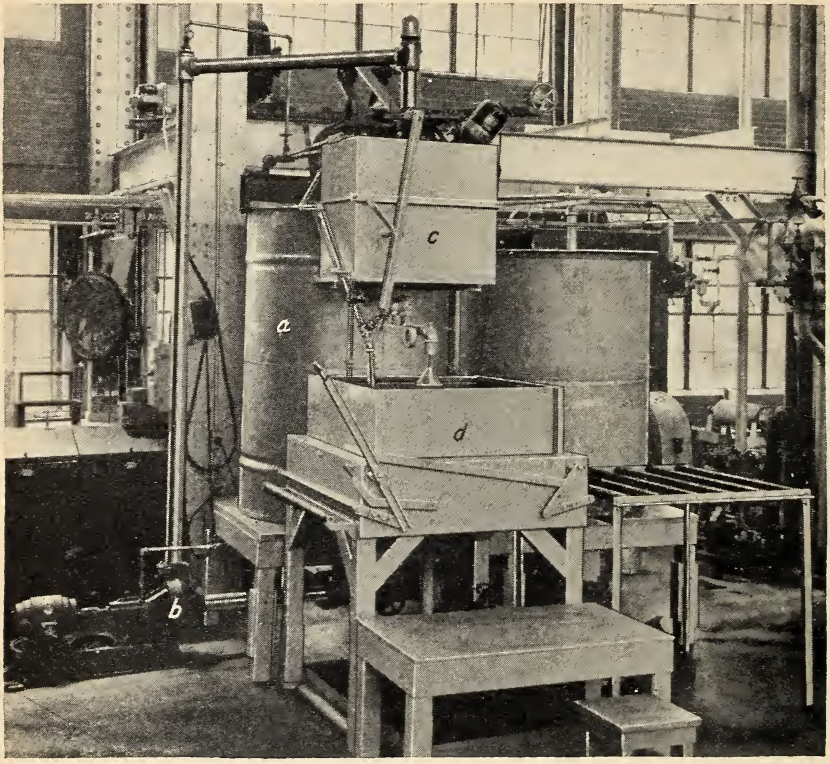

FIGURE 5.—Pilot-plant board machine showing: *a* Stock tank; *b* circulating pump; *c* metering-head box; *d* board machine and table rolls.

ing arrangement to feed the wet shredder at a uniform rate, the power required for shredding was cut in half. When the wet board was dried in the steam drier, the edges swelled so that the board required trimming. This extra operation of trimming was eliminated by placing a beveled shim on the bottom outside edge of the upper platen. The edges of the wet board made with this device were slightly thinner than the rest of the board (see fig. 8), but during drying the edges

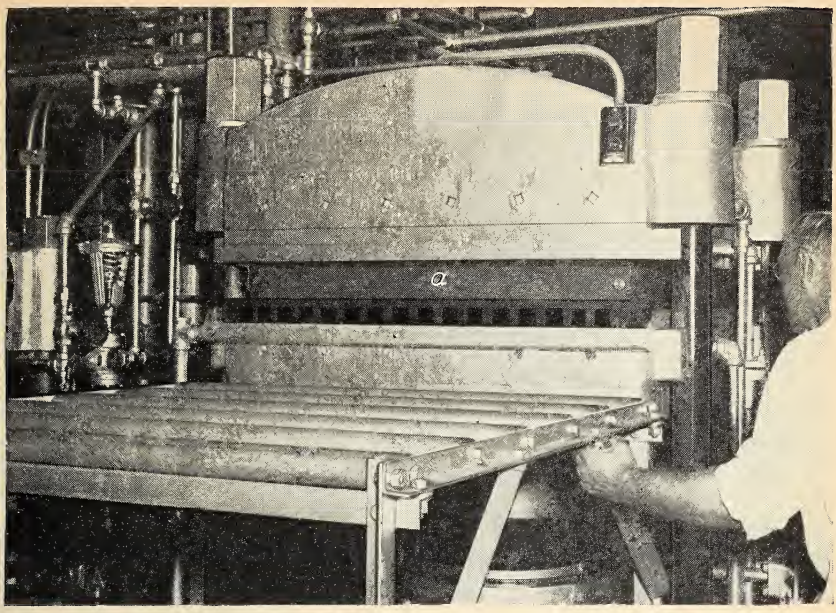

FIGURE 6.—Pilot-plant board press with table rolls. Board in press. *a*, Confining ring next to top platen.

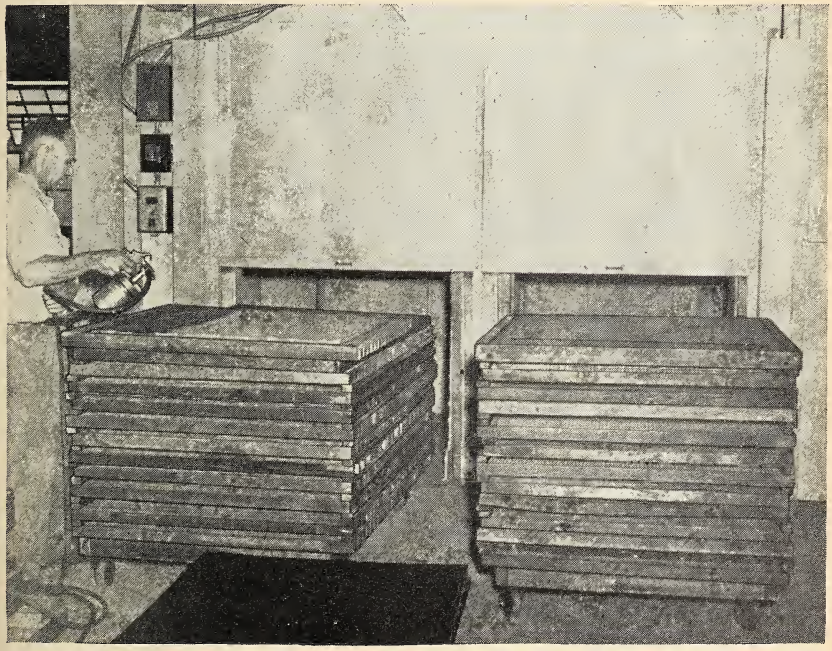

FIGURE 7.—Tunnel drier. Dry boards being sprayed with asphalt emulsion and piled.

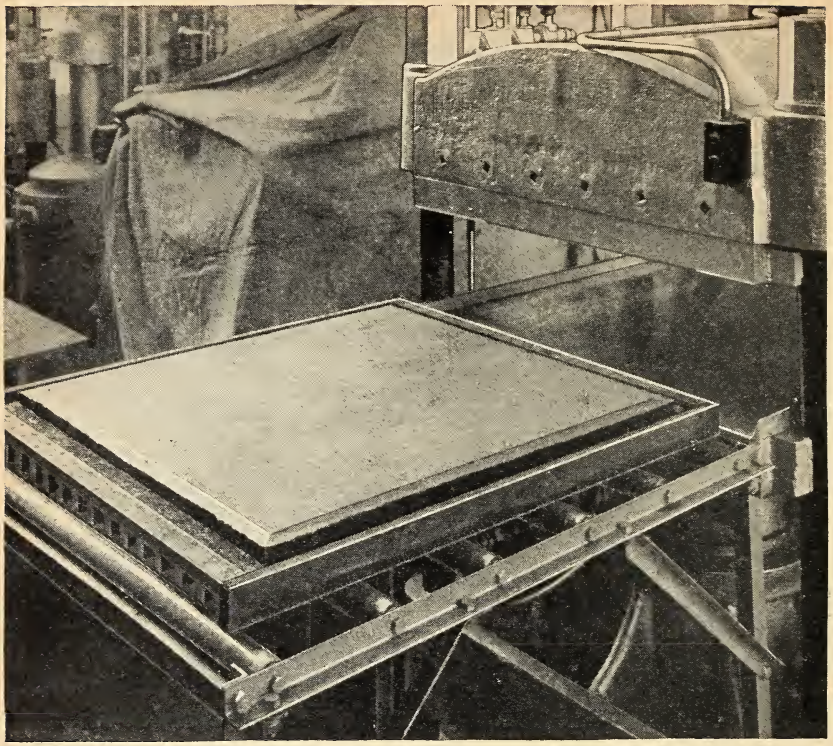

FIGURE 8.—Board after removal from press. Note beveled edges.

swelled to the final board thickness. The hot, dried boards were sprayed with a water-emulsion of asphalt and were then piled one on top of the other. The moisture in the emulsion was taken up by the boards, and thus they were properly seasoned for use.

Every step in this operation, as well as each piece of equipment, was studied on a pilot-plant scale. The board produced was 3 by 3 feet in size. It is planned to make the commercial board 4 by 4 feet in size. Design of the commercial plant equipment and careful cost estimates based on a daily production of 4,500 square feet were prepared from the results obtained in the pilot-plant experiments. A flow sheet of the operation is shown in figure 9, and figures 10 and 11 give a view of the suggested plan for a small operating plant including location of equipment.

ECONOMIC STUDIES

Estimates of Manufacturing Cost

Because of the uncertainty of postwar price structures, it is difficult to prepare reliable manufacturing cost estimates, particularly for labor, buildings, and equipment. The estimates given in table 1, for the most part, are based on quotations obtained during the war period. Naturally, costs will vary, depending upon the location of the plant and

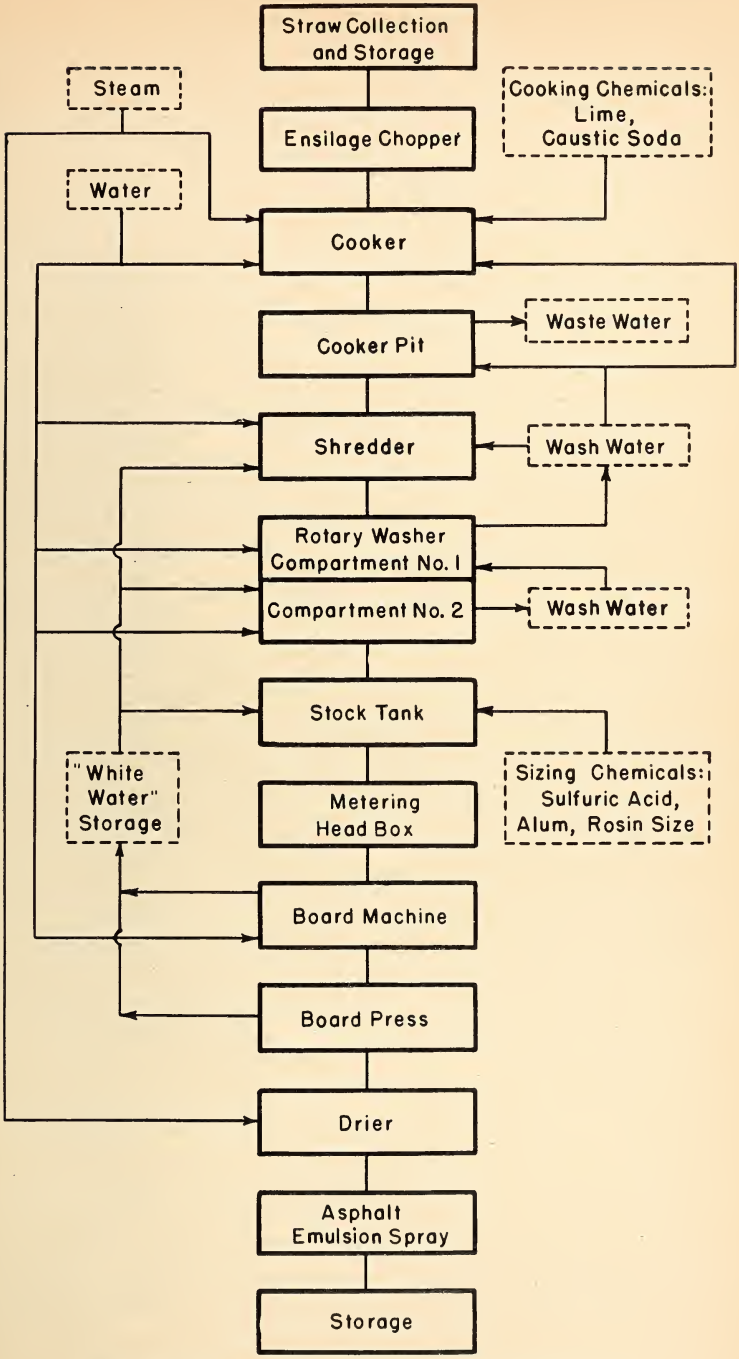

FIGURE 9.—Diagrammatic flow sheet of process No. 3.

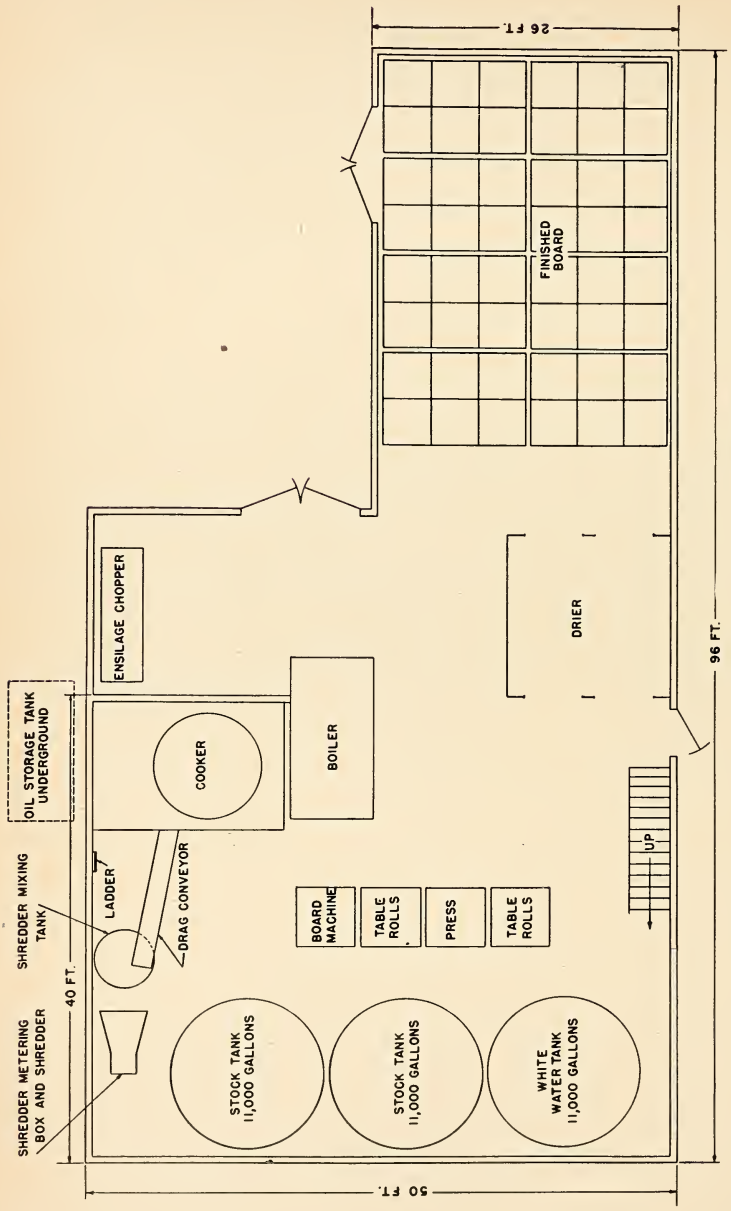

FIGURE 10.—First-floor plan of rural plant for making insulating board from straw.

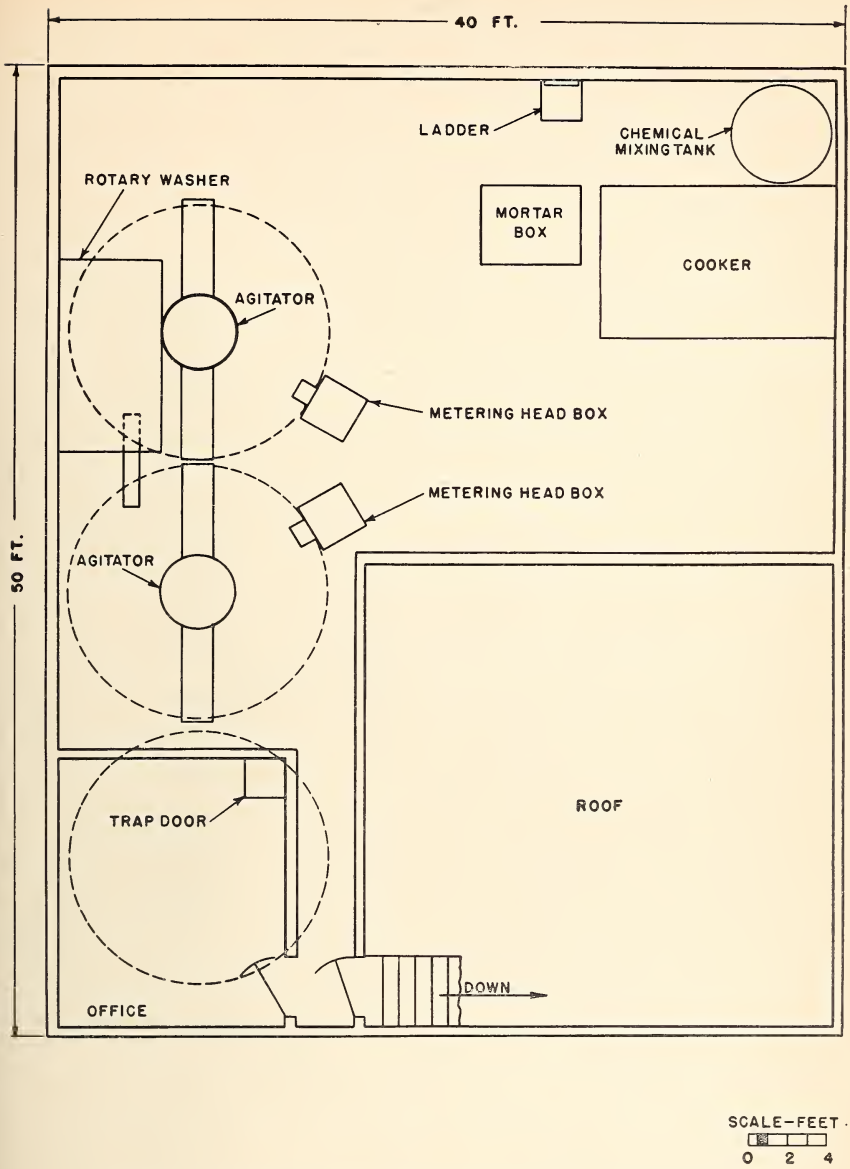

FIGURE 11.—Second-floor plan of rural plant for making insulating board from straw.

the time at which the plant is built. The cost factors used in arriving at the estimates in table 1 are clearly shown. In order to obtain reliable estimates, those considering rural operation of the insulating-board process must re-estimate the costs completely on the basis of local conditions and on up-to-date quotations on raw materials, equipment, and buildings.

TABLE 1.—*Estimated cost of production of $^{25}/_{32}$-inch insulating board from wheat straw*

Item	Unit cost	Per 1,000 square feet		Per month of 25 days (112,500 square feet production)		Per year of 300 days (1,350,000 square feet production)	
		Amount used	Cost	Amount used	Cost	Amount used	Cost
Materials:		*Pounds*	*Dollars*	*Pounds*	*Dollars*	*Pounds*	*Dollars*
Wheat straw	$5 per ton	1,640.0	4.10	184,500	461.25	2,214,000	5,535
Burned lime, CaO [1]	$10 per ton	62.7	.31	7,054	35.27	84,645	423
Flake caustic, NaOH [1]	$3 per hundredweight	3.5	.11	394	11.82	4,725	142
Dry rosin size, XXX	$4.75 per hundredweight	15.8	.75	1,778	84.46	21,330	1,013
Alum, $Al_2(SO_4)_3$ 18 H_2O [1]	$1.40 per hundredweight	40.1	.56	4,511	63.15	54,135	758
Sulfuric acid, technical [1]	$16.50 per ton	6.0	.05	675	5.57	8,100	67
Emulsified asphalt	$0.04 per pound	13.2	.53	1,485	59.40	17,820	713
Sodium chloride [1]	$15.70 per ton	13.3	.10	1,496	11.74	17,955	141
Total			6.51		732.66		8,792
Water, steam, and electricity:							
Water	$0.05 per 1,000 gallon	[2] 7,294.0	.36	[2] 820,575	41.03	[2] 9,846,900	492
Steam for cooking	$0.40 per 1,000 pound	2,082.0	.83	234,225	93.69	2,810,700	1,124
Steam for drying	$0.40 per 1,000 pound	6,633.0	2.65	746,213	298.49	8,954,550	3,582
Electricity	$0.015 per kilowatt hour	[3] 222.8	3.34	[3] 25,065	375.98	[3] 300,780	4,512
Total			7.18		809.19		9,710
Labor:							
Laborers per shift, 3	$5 per 8-hour day		10.00		1,125.00		13,500
Manager	$10 per 8-hour day		2.22		250.00		3,000
1 Common laborer per day	$4 per 8-hour day		.89		100.00		1,200
Social Security tax	3 percent of cost of labor		.39		44.25		531
Total			13.50		1,519.25		18,231
Total manufacturing costs			27.21		3,061.10		36,733

Fixed charges:							
Depreciation on cost of assets:[4]							
Building, cost $12,000	2 percent of cost		. 18		20. 00		240
Equipment, cost $38,000	12½ percent of cost		3. 52		395. 83		4, 750
Insurance and taxes	2 percent of capital		. 74		83. 33		1, 000
Repairs on equipment	6 percent of equipment cost		1. 69		190. 00		2, 280
Interest on $12,000 working capital	6 percent working capital		. 53		60. 00		720
Total			6. 66		749. 16		8, 990
Total production costs			33. 87		3, 810. 26		45, 723
Sales costs:							
Traveling expenses			1. 00		112. 50		1, 350
Local advertising			. 25		28. 13		337
Commission			2. 00		225. 00		2, 700
Total			3. 25		365. 63		4, 387
Total for all costs			37. 12		4, 175. 89		50, 110

[1] Quotations for October 1945.
[2] Gallons.
[3] Kilowatt-hours.
[4] For further advice concerning depreciation, see your local Collector of Internal Revenue.

Capital investment is estimated at $50,000 of which approximately $12,000 is the cost of new buildings and $38,000 the cost of equipment installed. Working capital is estimated at $12,000. Based on these figures, fixed charges per 1,000 square feet of $^{25}/_{32}$-inch insulating board are estimated at $6.66, which, together with $27.21 direct manufacturing expense, gives a total cost of $33.87. This cost is much higher than that of insulating board made in existing large-scale factories. If buildings are available locally or if some of the equipment can be obtained from war-industry surpluses, the capital investment may be lowered with consequent lower fixed charges.

Merchandising and Estimated Profit

Insulation sheathing board ($^{25}/_{32}$-inch) is being merchandised in two ways. The main sales channel is through lumber dealers and building-material supply organizations which purchase at dealer prices from the large manufacturers. The dealer price includes freight to dealers' yards, together with a very considerable amount of merchandising and advertising help supplied by the manufacturer. The second channel of distribution to the contractor and retail trade is through mail-order houses that sell the product at $50 per 1,000, free on board, Iowa, on the Mississippi River. Sales prices by lumber or building supply dealers vary from about $65 per 1,000 for small retail purchases to more than $50 to contractors carrying on large building projects.

Fifty dollars per 1,000 square feet is, therefore, the top price at which the product of the rural industry may be expected to sell. Although the product can be made to meet fully the strength and insulation values of standard insulating board, it cannot be expected to be either as uniform or as attractive merchandise as that of the large manufacturers, and it would not be wrapped in bundles. It is doubtful, therefore, whether the product could command a price of $50 per 1,000 square feet.

It is very difficult to estimate the cost of selling the board in the rural community, and a careful study of probable sales costs would have to be made by anyone who considers the undertaking of rural manufacture of insulating board. The assumption has been made that a commission of $2 per 1,000 square feet would be paid for selling and $1 for travel, making a total sales cost of $3 per 1,000 square feet. This cost may be too low, in which case the estimated profits shown in table 2 will have to be revised accordingly. Because of the high cost of manufacture, it will not be possible to merchandise the board through dealer outlets which often operate on a 50-percent mark-up. The product must be sold directly to the user and, in most cases, free on board, plant. Twenty-five cents per 1,000 square feet is allowed for advertising; that is, simple literature describing the product and its uses and modest local advertising in the newspapers.

Some of the board produced will not be up to standard, but in most cases sale for the substandard product probably can be found at a reduced price. The estimated annual income and profit data shown in table 2 are based on the production of 5 percent of substandard board which can be sold at an average price equal to the total cost of

TABLE 2.—*Estimated annual income and profit on capital investment based on production of 1,350,000 square feet of 25/32-inch insulating sheathing board*

Item	Selling price for grades No. 1 and No. 2, respectively				
	$40 and $32.50	$42.50 and $35	$45 and $35	$47.50 and $35	$50 and $35
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Income from 1,280,000 square feet of No. 1 insulating board 25/32-inch thick	51, 200	54, 400	57, 600	60, 800	64, 090
Income from 70,000 square feet of No. 2 or substandard insulating board	2, 275	2, 450	2, 450	2, 450	2, 450
Total income	53, 475	56, 850	60, 050	63, 250	66, 450
Total cost	50, 110	50, 110	50, 110	50, 110	50, 110
Net profit	3, 365	6, 740	9, 940	13, 140	16, 340
Return on capital investment prior to Federal taxes—percent	6. 7	13. 5	19. 9	26. 3	32. 7

manufacture. The table gives an estimate of the profits to be expected from the operation, depending on the average sales prices obtained. It is evident that idleness resulting from any cause will seriously affect the profits. For example, fixed charges amount to $750 per month, which, together with the manager's salary of $250 per month, equals $1,000. The total cost of 1 month's production, in turn, is estimated at $3,811. It is evident, therefore, that carelessness in manufacturing, lack of sales ability, and poor business management will quickly and seriously affect profits.

Conditions Required for Successful Operation

The location of the plant is of major importance. If it is assumed that 3,000 square feet of board will be used in the average building, from 300 to 400 sales per year will be required to move the annual production of the plant. The trading area in which the plant is located must, therefore, be such that for a period of at least 10 years, during which the plant is amortized, 3,000 to 4,000 structures using approximately 3,000 square feet each will be built or remodeled. The radius and character of the trading area must be such that transportation costs are low enough that the purchasers will be willing to get the board at the plant. Selling outside of the local area would involve more competitive merchandising and would result in lower profits.

The plant must be located in an area where farmers will be willing to contract to collect, bale, deliver, and pile 1,200 tons of straw annually at the plant site. Contracts should be made directly with farmers in order to insure them maximum profit for the straw and for their labor. The hauling radius from the plant should be less than 10 miles and preferably no greater than 5 miles to insure reduced hauling costs.

The plant should be located in a small community where it may become an important business and in which living costs are relatively low. This community should be located on the edge of the main trading center, on a main highway, and preferably, on a railroad. A fresh-water supply will be required, and a stream or river into which about 50,000 gallons of waste water per 24 hours may be run without danger of serious stream pollution is necessary. The effluent will have a biological oxygen demand of 182 parts per million, equal to the sewage of a town of 450 population. Two or three straw ricks will be required, which must be covered with tarpaulins or asphalt paper to prevent damage by rain and snow. Fire regulations usually require that these ricks be situated at least 100 feet from a building, but it would be advisable to contact local authorities on this matter.

Business management will be the controlling factor in the success of the operation. There is no exception for this either in large or small business, but the small business cannot generally weather strikes, business depressions, and the like as easily as a large business.

Taking these requirements into account, it is evident that a thorough study and survey is necessary before coming to a conclusion as to the advisability of undertaking the establishment of an insulating-board industry in a rural community. Localities can probably be found where the business will succeed in a healthy fashion. Management of the industry by a successful farm cooperative might be logical. Under less-than-ideal conditions as to markets, costs, and

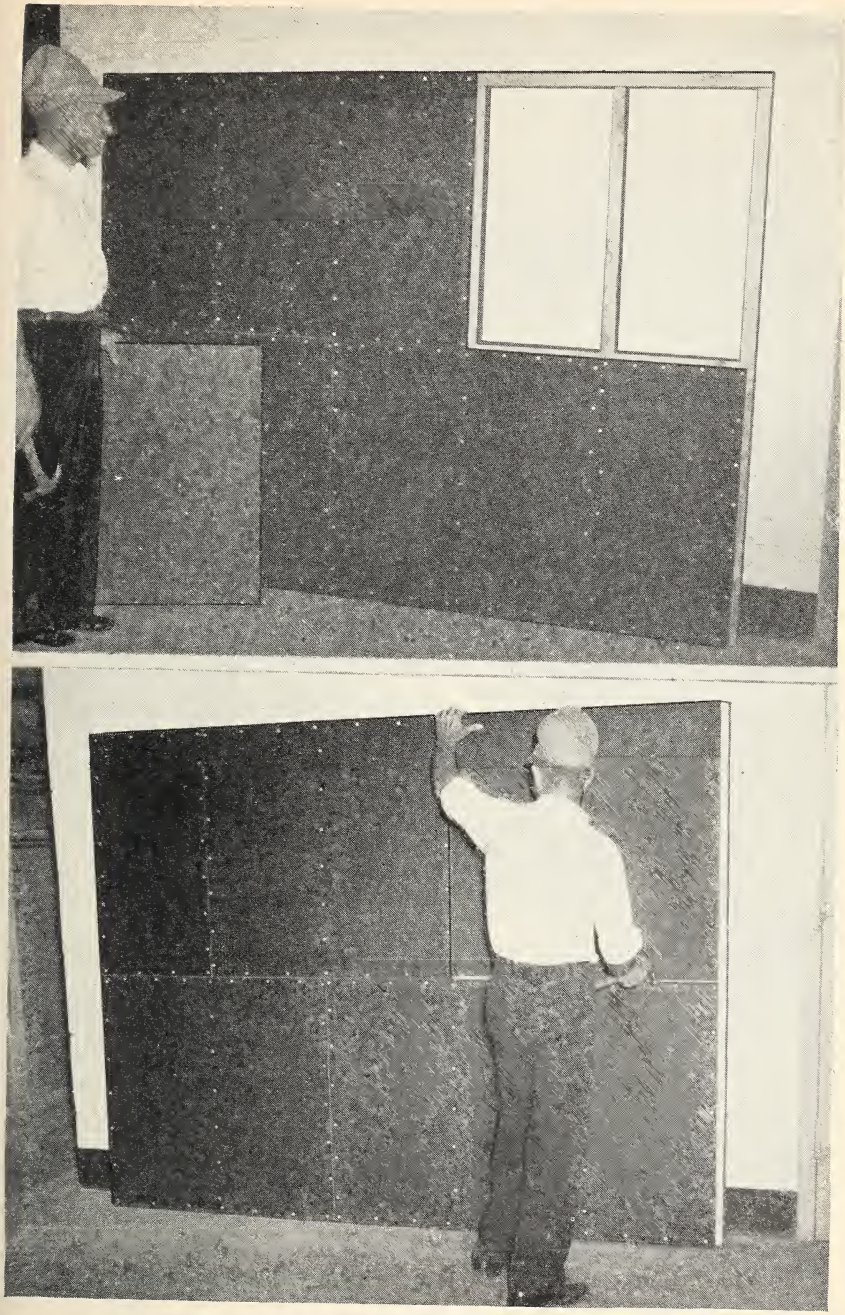

FIGURE 12.—Applying 3-foot pilot-plant board to framing.

business management, the venture is likely to fail or to be of a marginal character. The processing of insulating board is suited to islands or foreign countries where labor costs are low, transportation costs are high, and insulating building materials are not manufactured on a large scale.

The method of using insulating board in a typical farm structure is shown in figure 12.

A supplementary report has been prepared in which the details of equipment design and costs, building layout and costs, pilot-plant investigations, and directions for operating insulating-board plants are presented. This information will be made available to those considering the establishment of a rural insulating-board industry if they will visit the Northern Regional Research Laboratory in Peoria, Ill., where the process can be demonstrated and where questions can be answered in more detail than is possible in this report.

SUMMARY

1. A process for manufacturing from wheat straw 4,500 square feet per 24-hour day of 25/32-inch insulating sheathing board, 4 by 4 feet in size, has been fully worked out through pilot-plant-scale operations.

2. The sheathing board can be made to compete in utility, structural strength, and water resistance with present competitive products, although it will not quite compete in degree of uniformity or in attractiveness.

3. An estimate has been made of manufacturing and selling costs and of possible profits.

4. Manufacturing costs are very much higher than those involving large-scale manufacturing methods, and the margin of profit is small.

5. Because of the small profit margin, the product must be sold directly to the user, free on board plant, unpackaged.

6. Ability to sell the product and sound business management are even more important than manufacturing ability in the success of the small rural insulating-board plant.

7. In many localities the process would prove uneconomical or marginal. In localities where straw is plentiful, transportation costs are high, and the production of the plant can be absorbed in a restricted trading area for at least 10 years, the process would have chances of success. Management by an established cooperative would seem to be logical.

8. It was not possible by the methods tried to develop an insulating-board process that is economical for use on the farm. The best balance between raw materials and labor costs, on one hand, and fixed charges, on the other, seems to have been reached in the size of plant proposed in this publication.

9. This study brings into clear perspective the economic, merchandising, business, and manufacturing problems of the small rural plant for making nonfeed or nonfood products from agricultural materials in competition with large-scale, highly mechanized industries that make and distribute established products on a national scale.

U. S. GOVERNMENT PRINTING OFFICE: 1947